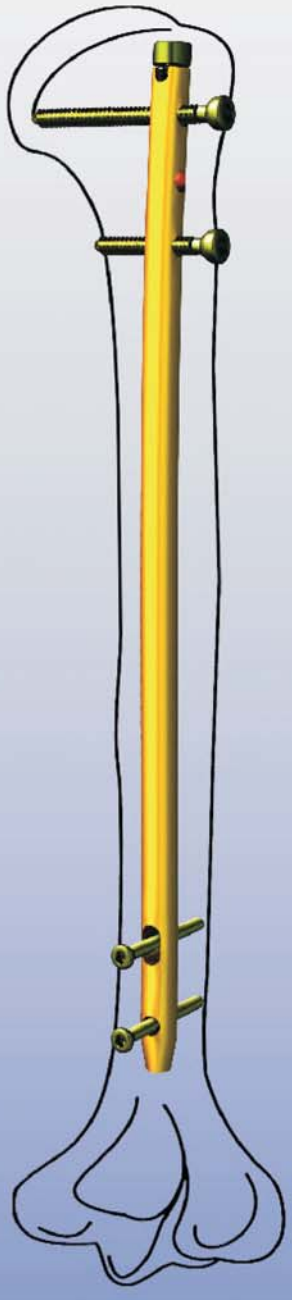
KANGHUI
medical

Orienail – II Humeral Nail System

SURGICAL TECHNIQUE



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Introduction

Intramedullary nailing offers the benefits of anatomic alignment, rigid fixation with limited soft tissue dissection, and early rehabilitation of the injured limb. However, intramedullary nailing indications for humeral fractures should be viewed with caution. The anatomy and function of the humerus are quite different from the long bones of the lower extremity:

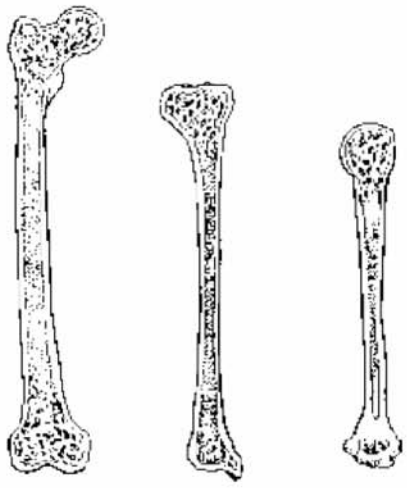


Figure 1 Comparison of three long bones

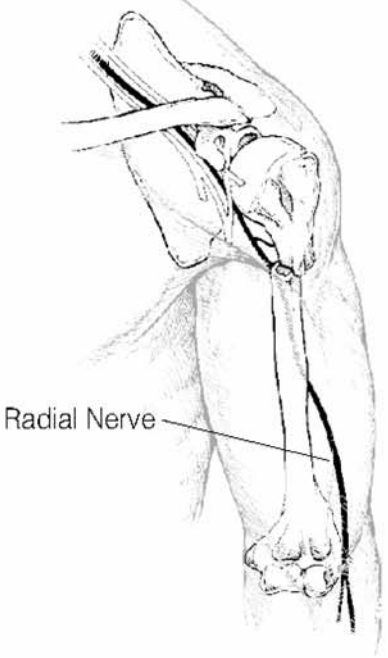


Figure 2

- The humerus is not a "weight-bearing" bone,therefore, rigid internal fixation is not needed to maintain limb function during fracture healing.
- Whereas the intramedullary canal widens in the metaphyseal area of the tibia and femur, the humeral canal narrows, significantly increasing the risk of distal fragment comminution(Figure 1).

  The anatomy of the upper arm also predisposes the patient to an increased risk of soft tissue injury, particularly the rotator cuff.
- The potential for neurovascular injury is greater in humeral nailing than in the nailing of lower extremity fractures (Figure 2).

Before embarking on humeral nailing, one should understand the obstacles that can be encountered. Adequate planning will minimize these difficulties. Rotator cuff injury, proximal humerus articular cartilage destruction, radial nerve injury, and extension of comminution are all possible complications of this procedure.

Patient Positioning

The patient should be positioned on a radiolucent table that allows access to upper extremity viewing with the C-arm. The C-arm should be positioned on the patient side opposite of the fracture to improve exposure of the humerus and allow for easy passing of instrumentation.
The patient should be positioned supine. A roll is placed under the scapula which extends the operative shoulder to expose the humeral head from under the acromion (Figure 3).

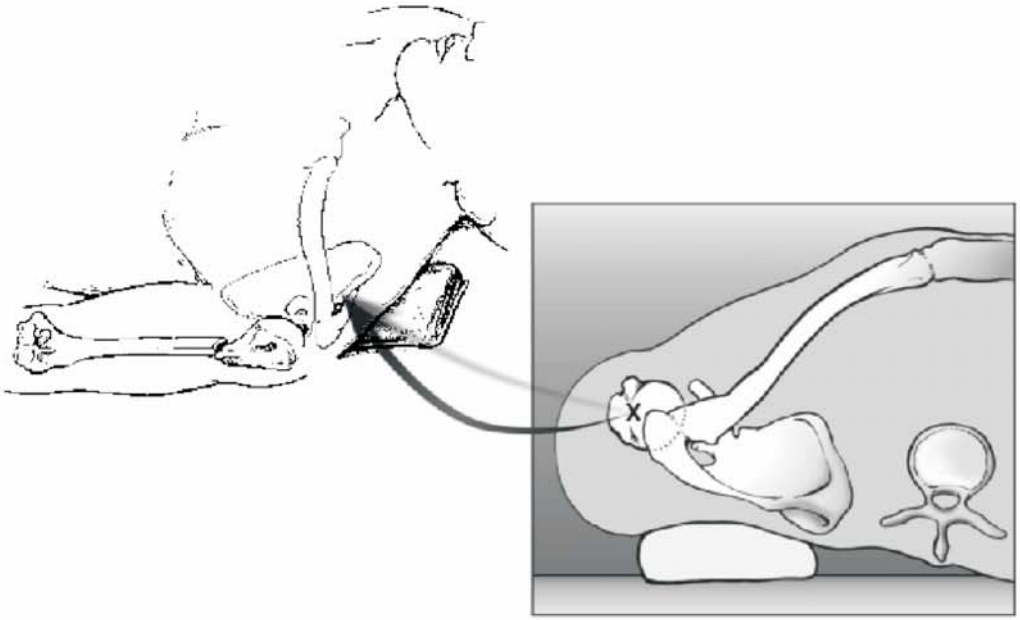


Figure 3

Incision Planning

When performing nailing of proximal humerus fractures, the proximal fragment is commonly in a marked varus position secondary to contraction of the rotator cuff. To initiate entry site and plan rotator cuff incision, it is important to fully adduct the proximal humerus fracture (Figure 4a, 4b).

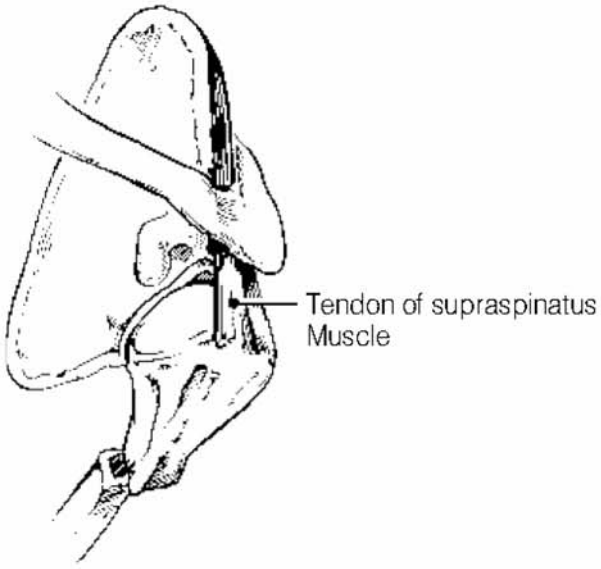


Figure 4a

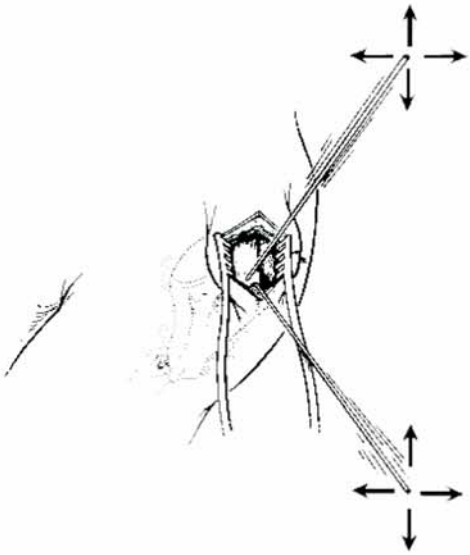


Figure 4b

A 3cm incision is usually adequate to perform nailing of the humerus. The skin and subcutaneous tissues are incised sharply. Elevation of the subcutaneous fat from the deltoid epimysium is helpful to expose the fascial plane between the anterior and middle third deltoid muscle fibers. An incision in line with the deltoid fibers or spreading of the muscle fibers with blunt dissection can be performed. The subdeltoid bursa is then encountered. Sharp dissection of the subdeltoid bursa from the rotator cuff is recommended to assure visualization of the direction of the fibers of the supraspinatus tendon. Prior to rotator cuff incision a K-wire should again be utilized to identify the optimal entry site.

To decrease rotator cuff trauma and postoperative complication, it is mandatory to perform the incision of the rotator cuff in the plane of the supraspinatus fibers directly over the cortical entry site. Place the incision of the rotator cuff sufficiently medial to its insertion site on the greater tuberosity. The rotator cuff does not have enough mobility near its insertion to allow adequate migration from nailing instruments. By proper planning of the incision, the trauma to the rotator cuff can be minimized.

After the rotator cuff incision is complete, it is very helpful to utilize Sutures and mark each side of the incision. The Ethicon sutures also help to retract the rotator cuff during preparation of the entry site and during intramedullary nailing. Tying the suture following completion of intramedullary nailing also provides a good method of closing the rotator cuff(Figure 5).

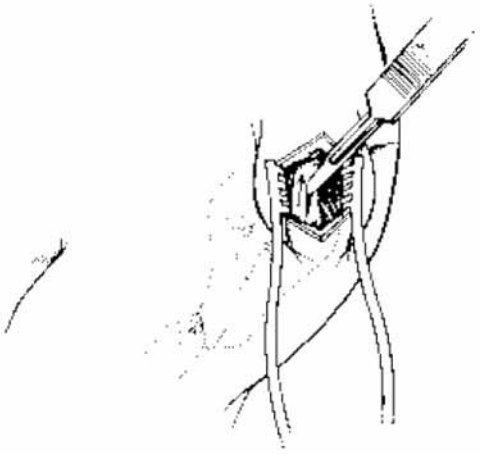


Figure 5

Entry Site Preparation

Using the straight entry reamer, the medullary canal is opened 1cm to 1.5cm medial to the greater tuberosity, in line with the medullary canal. The entry reamer is cannulated and can be inserted over a guide pin. The straight entry reamer is assembled onto the power adaptor which inserts into the drill. Do not use this reamer for midshaft or distal canal reaming. Do not insert the reamer past the safety line indicated on the shaft of the entry reamer(Figure 6).

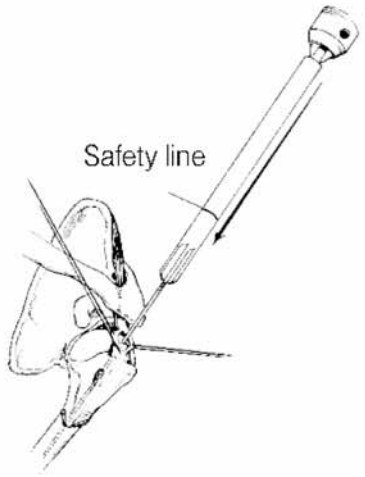


Figure 6

Reduction

Reduction of humeral fractures usually proceeds smoothly with longitudinal distraction by an assistant.

Nail Length Selection

Selection of the proper nail length is more critical in the humerus than in the femur or tibia. Proper proximal nail placement with the end cap installed is approximately 5mm below the articulating surface. End caps that are flush, 1/2cm or 1cm in height are included to allow nail length adjustment. Proper positioning will reduce the chance for nail migration, canal penetration and ultimately ease nail extraction.

Guide Wire Method

Prior to nail impaction, suction the reamed bone remnants from the distal portion of the canal. This will increase the accuracy of the measured length and reduce the potential for excessive compaction when inserting the nail. With the distal end of the ball nose guide wire 1cm–2cm proximal to the olecranon fossa, overlap a second guide wire by inserting it approximately 1cm inferior to the articulating surface and extending proximally from the entry site. Measure in millimeters the length of the overlapped wires. Subtract the measured length from 965mm to determine the nail length (Figure 7a).

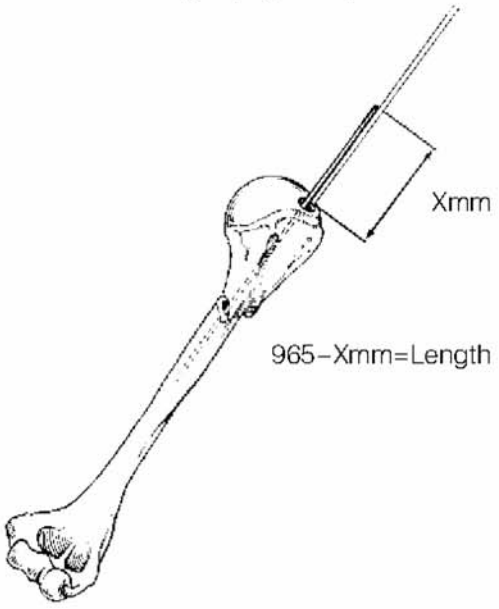


Figure 7a

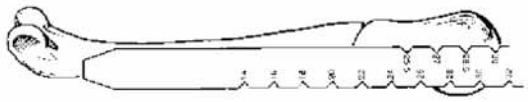


Figure 7b

Radiographic Ruler Method.

The radiographic ruler may be placed adjacent to the affected humerus and viewed under image intensification to determine the appropriate length nail (Figure 7b).

Note: Nail length should be selected to allow for impaction and still assure that the nail's final proximal position is beneath the proximal cortex.

Nonreamed Applications

In nonreamed applications, the proximal portion of the medullary canal must be opened to a minimum depth of 7cm to accommodate the nail's 9mm proximal diameter in the 7–9mm diameter nails.

Reaming Applications

If reaming is required, the fracture is reduced first. The guide pin grip is attached to the ball nose guide wire to assist in manipulating the wire across the fracture site. The canal is reamed in 0.5mm increments over the 3.0mm ball nose guide wire to 1mm larger than the selected nail diameter. Never insert a nail that has a larger diameter than the confirmed size of the last reamer used. Since the cortical bone thins from proximal to distal, use caution when reaming. Overreaming will decrease the accuracy of the measured length and increase the potential for excessive compaction.
After reaming, insert the exchange tube over the ball nose guide wire and then remove the guide wire through the exchange tube. Be careful to keep the distal tip of the exchange tube inferior to the fracture site.

Jig Assembly

Proximally, the orienail-II Humeral Nail has a 2.5° lateral bend. The apex of the bend in the nail should face medially. While holding the hub adaptor (A), insert the hex of the hub fastener (B) into the hex socket in A (Figure 8). Next, slip the keyed hub (C) over the shaft of B (Figure 9). There is an assembly diagram on the instrumentation module for your reference. The assembled parts are held in one hand, and the nail is held in the other. The keys on C are inserted into the matching keyways at the proximal end of the nail (Figure 10). The bend of the nail must match the nail diagram on C (inset). Part A is used to tighten B into the nail' s proximal screw threads. A is then removed. C and B will remain securely fastened to the nail. The combination jig (D) is then slipped over the threaded portion of B and the pin is inserted into the proper hole on C. For distal locking first, proper hole alignment is indicated when the word "distal" on C lines up with the word "left" or "right" on D (Figure 11). Tighten the system with A (Figure 12).

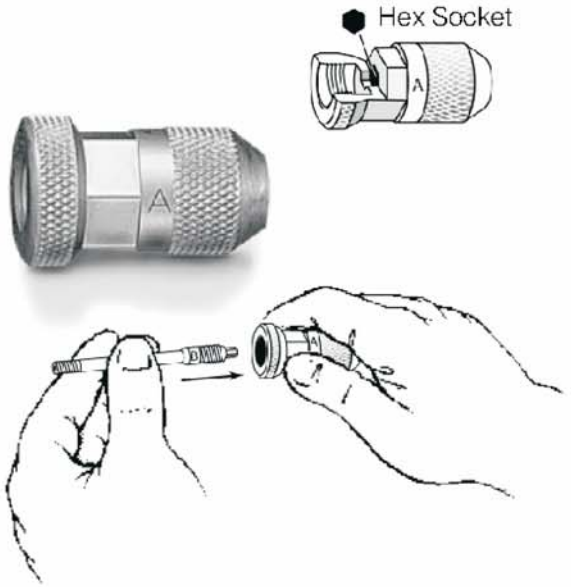


Figure 8

Figure 9

Next, slip the keyed hub (C)over the shaft of B.

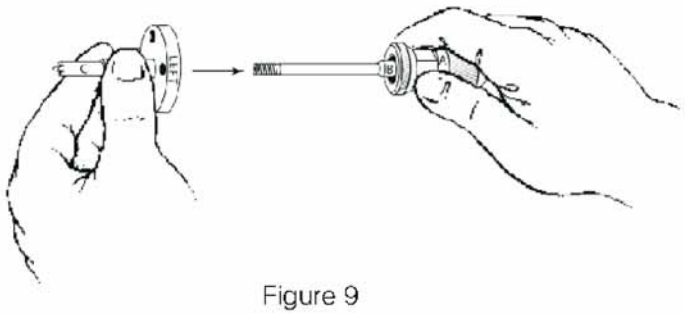


Figure 9

Figure 10

The assembled parts are held inone hand, and the nail is held in the other. The keys on C are inserted into the matching keyways at the proximal end of the nail.

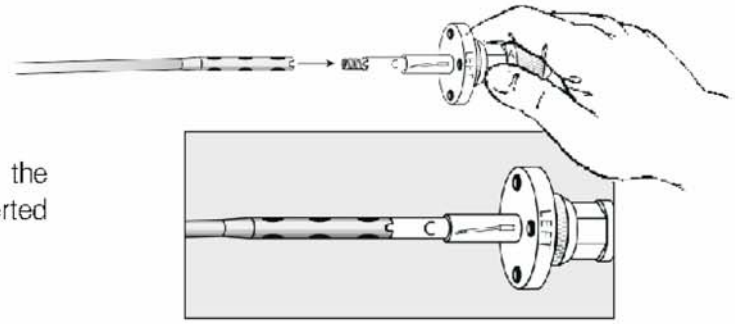


Figure 10

Figure 11

The combination jig (D) is then slipped over the threaded portion of B and the pin is inserted into the proper hole on C. For distal locking first, proper hole alignment is indicated when the word "distal" on C lines up with the word "left" or "right" on D.

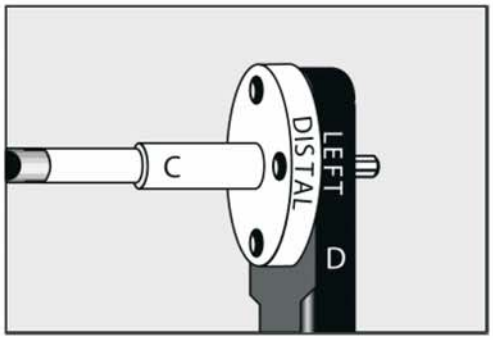


Figure 11

Figure 12

Tighten the system with A.

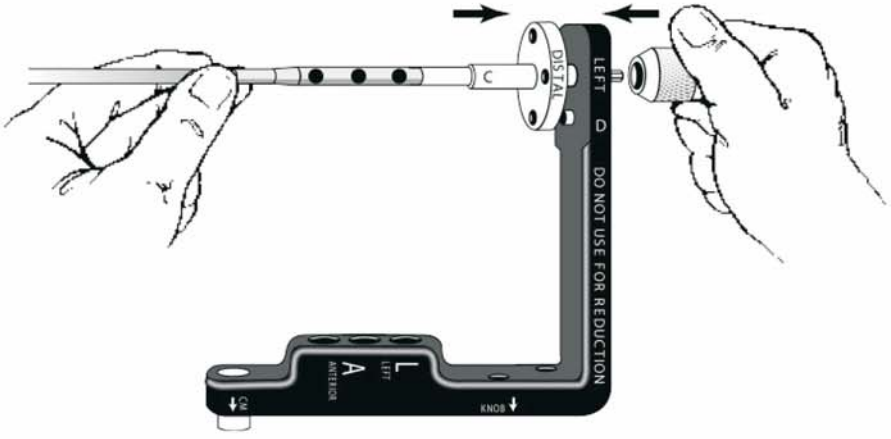


Figure 12

To attach the distal jig to the combination jig, first find the centimeter marking on the side of the distal jig which matches the length of the nail being inserted. The corresponding round hole on the front of the distal jig is slipped over the distal pin on the combination jig (Figure 13). Place the distal jig onto the combination jig using the locking knob.To confirm correct jig alignment insert the sheath and trochar through the holes in the radiolucent portion of the distal jig. The sheath and trochar must line up with the distal screw hole in the nail. Once this has been confirmed, tighten the locking knob (Figure 14).

Figure 13

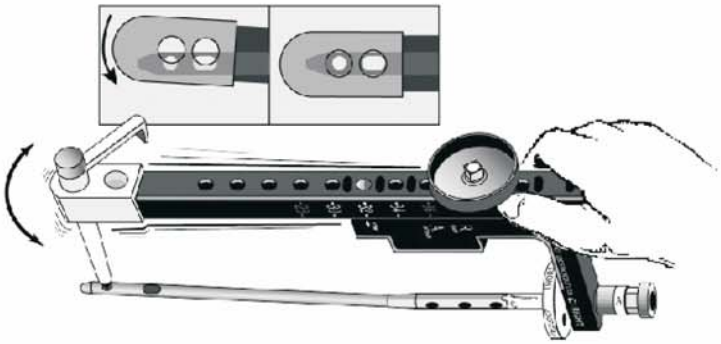


Figure 14

Note: For extremely proximal humeral fractures, proximal interlocking can be performed first.

Nail Insertion

Securely tighten the hub adaptor with the 3/4 inch combination wench. The slide hammer is assembled onto the impactor rod. This assembly is then threaded into A.

Before nail insertion, consideration should be given to the desired location of the nail' s proximal screw holes relative to the fracture pattern. Proper nail placement with the end cap installed is approximately 5mm below the articulating surface. The nail is inserted over the 3.2mm driving guide wire (7mm diameter nails do not use the driving guide wire) through the entry site and driven into the canal with light to moderate downward blows of the slide hammer (Figure 15). If the nail does not advance easily with each blow remove it and ream an additional 0.5mm. To avoid splitting the distal humerus, care should be taken not to overdrive the nail distally or wedge the nail tip too close to the olecranon fossa. The hub adaptor and combination screw jig should remain securely attached to the nail until all the interlocking screws have been installed. Remove the impactor/slide hammer assembly.

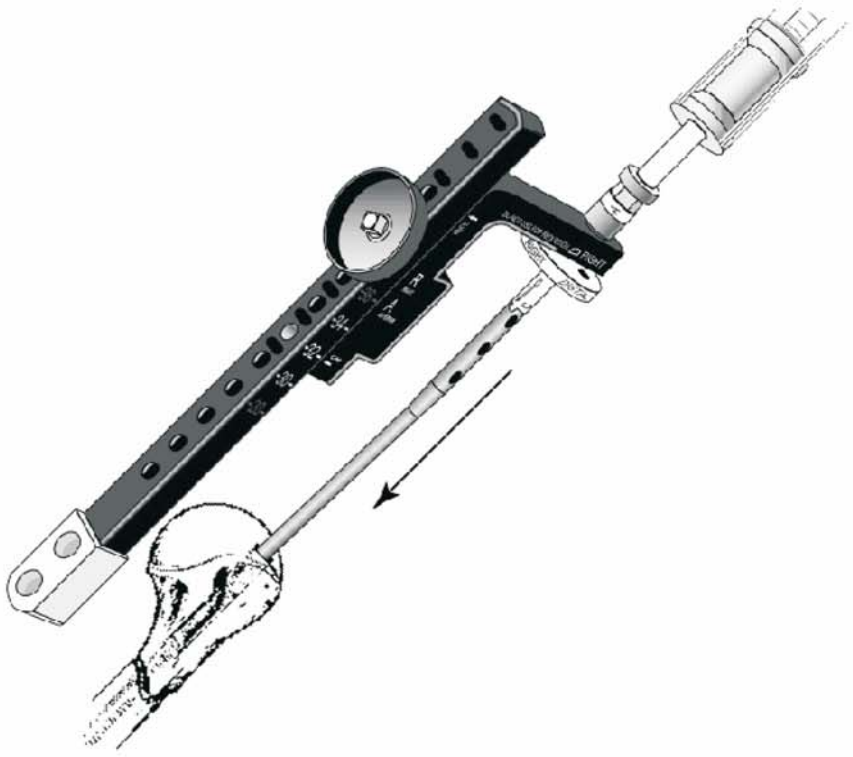


Figure 15

Note: If the fracture pattern is amenable to impaction, nail length should be selected to allow for this and still assure that the nail's final proximal position is beneath the proximal cortex.

Distal Interlocking

The jig is used as a guide for the distal incision site placement. The incision is made through the skin longitudinally and blunt dissection is performed through the biceps directly to the humerus. An open approach using a finger to palpate the position of the screw sheath and trochar over the center of the humerus is recommended (Figure 16). Caution should be exercised to utilize drill guides at all times during drilling to avoid danger to the lateral antebrachial cutaneous nerve. Finger palpation is encouraged to assure that drill guide contact is maintained throughout the procedure. To insert the first distal screw, first determine the proper drill size. The 7 and 8mm diameter nails use 3.5mm diameter screws which correspond with the 2.9mm drill. All other nail diameters use 4.5mm diameter screws which correspond with the 3.8mm drill. The guide is a guide, not a jig, and therefore, an open approach is required to assure that no significant contact between the soft tissue and the drill guide is present. The screw sheath should glide up and down freely to verify that soft tissue contact is not misdirecting the guide. Remove trochar and thread the desired drill guide into the screw sheath. Drill the pilot hole for the first distal screw using the appropriate drill (Figure 17). The drill bit is inserted through the drill guide and drilled through both cortices of the bone. Make sure that the drill bit's cutting tip protrudes through the far cortex (see inset). The appropriate screw length is determined by reading the first visible drill calibration shown at the end of the drill guide. Remove the drill and drill guide. Select the appropriate screw and guide it into the bone through the screw sheath using the appropriate 2.5mm or 3.5mm screwdriver assembled onto the quick connect round handle.Confirm final screw placement radiographically.

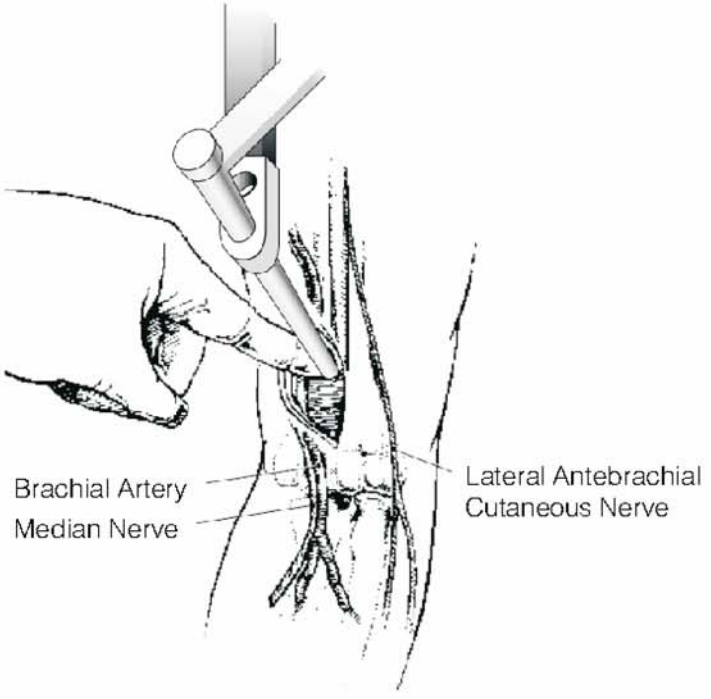


Figure 16

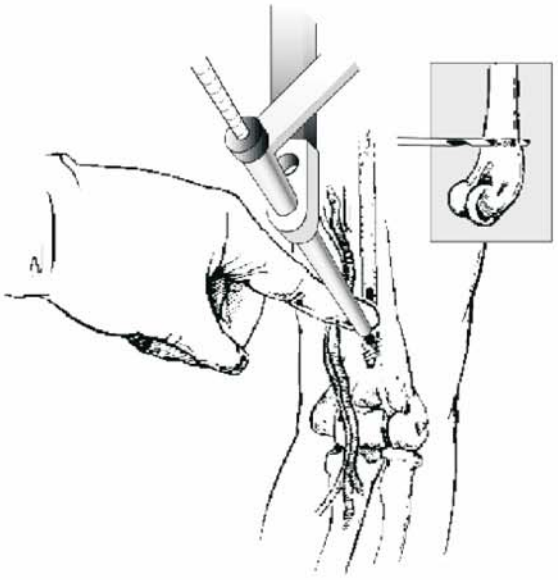


Figure 17

Insert the second distal screw, reassemble the screw by the saml method.

If site impaction is selected, remove the distal jig from the combination jig. Prior to proximal locking, impact the fracture site by assembling the slide hammer onto the hub adaptor and applying gentle retrograde blows of the hammer. Verify adequate fracture site impaction radiographically.

Proximal Interlocking

Unlike other long bone intramedullary nailing proce dures, the entry site for a humeral nail requires an articular approach. There is a possibility of impingement against the acromion or damage to the rotator cuff with any proximal nail migration. For that reason, it is mandatory to lock the humeral nail proximally in all nailing applications.

Proximal interlocking is achieved with either 4.5mm solid cortical screws or 5.0mm cancellous lag screws. Either of these screws may be installed in any of the nail' s three proximal locking holes. Screw selection will depend upon the fracture pattern and quality ofbone. The 4.5mm cortical screw uses a 3.8mm drill bit for hole preparation. The 5.0mm cancellous lag screw uses a 3.6/4.9mm step drill. The 5.0mm cancellous lag screw should pass through the nail and into cancellous bone in the humeral head as farmedially as practical without penetrating the medial cortex.

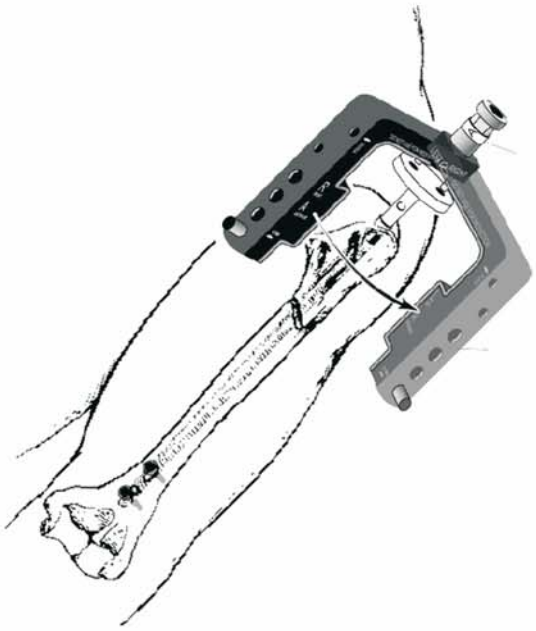


Figure 18

Figure 19

The combination jig must be rotated 90° from itsdistal locking position to perform proximal locking(Figure 18). To achieve this, loosen the hub adaptor A. When sufficiently loosened, the combination jig D is lifted away from the surface of the keyed hub C until the pin in the combination jig disengages from the keyed hub. The jig is then rotated 90° and lowered back onto the keyed hub so that the jig pin engages the correct hole in the keyed hub. The correct hole is indicated when the word "left" or "right" on the combination jig aligns with the word "left" or "right" on the keyed hub, respectively.

Initiate proximal screw insertion by threading the trochar into the screw sheath. To identify the screw entry point, the screw sheath and trochar assembly is inserted through the desired hole in the combination jig to the skin. The assembly is retracted to allow a stab incision to be made into the skin. Dissect bluntly through the subcutaneous tissues and deltoid muscle to the lateral cortex. This dissection keeps the remaining branches of the axillary nerve and muscles out of the way during drilling and screw placement. The trochar and screw sheath assembly is reinserted and gently tapped into the lateral cortex (Figure 19). The trochar is then removed.

After selection of screw type, select the drill guide to match the type of drill bit to be used (inset). Thread the drill guide into the screw sheath. The appropriate drill bit is assembled to the power adaptor and drilled. Care should be taken to avoid over-drilling the medial cortex. Over penetration can lead to damage of the axillary vein and other significant neurovascular structures. The drill bit is advanced under power through the drill sleeve to the appropriate screw depth. The outer sheath should remain in contact with the bone throughout this procedure. Use the C-arm to monitor appropriate drill depth during the drilling procedure.

Screw lengths can be determined by reading the calibration on the drill bit at the end of the drill guide. Alternatively, the sliding hook depth gauge can be inserted to the bone through the screw sheath (Figure 20).

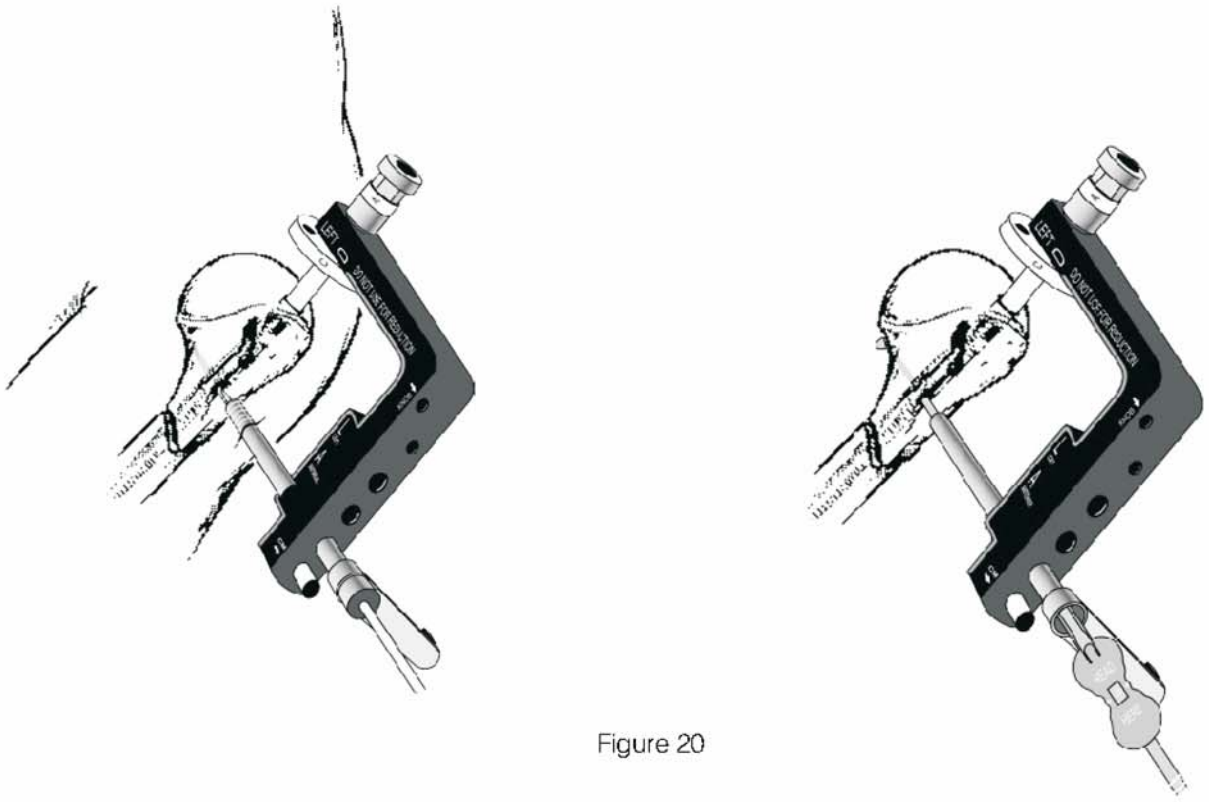


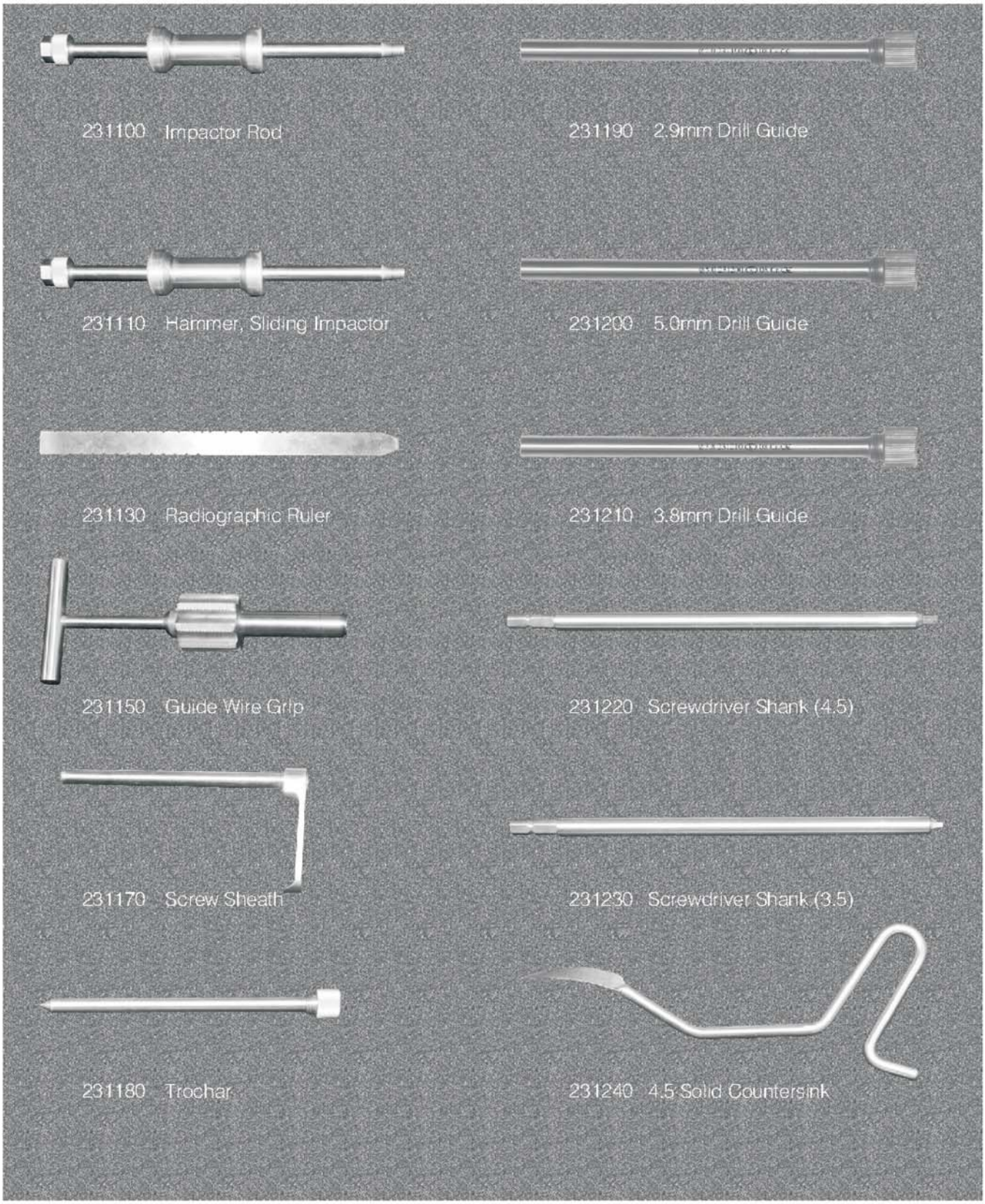
Figure 20

Note: For an accurate reading makesure that the sheath assembly is seatedon the bone.

Remove the drill guide, if still inserted. Prior to screw insertion, consider the countersink option. Insert the selected screw through the outer sheath using the screwdriver assembled onto the quick connect round handle. Screw placement is confirmed with image intensification in both the AP and near lateral views. The second and (optional) third screws are inserted using the previously described technique. The third proximal hole allows good bicortical purchase. However, use caution when drilling toward the axillary vein and peripheral nerves.

Once all the interlocking screws have been installed, the hub adaptor and combination jig assembly can be removed, by loosening the hub adaptor. If necessary, the hub adaptor may be loosened with the 3/4 inch wrench and the keyed hub held in place with the hub wrench inserted through the underside holes of the keyed hub.

Instruments Introduction



231250 Round Handle

231260 Power Adaptor

231270 Depth Gauge

231280 3.8mm Calibrated Twist Drill

231290 2.9mm Calibrated Twist Drill

231300 3.6/4.9mm Calibrated Step Drill

231310 Guide Pin (3.2mm x 14 in.)

231320 3/4 in. Wrench

231350 Hub Adaptor

231360 Hub Fastener

231370 Keyed Hub

231380 Combination Jig

231390 Distal Jig

231400 Locking Knob

231410 2.5mm K-Wire

231420 Entry Reamer (9.5mm)

231500 7mm Flexible Reamer

231510 8mm Flexible Reamer

231520 9mm Flexible Reamer

231530 Plain Guide Wire,

231540 Guide Wire With Olive

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